Applications of SMART: a DRDC atmospheric radiative transfer library optimized for wide band computations

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- Conclusion

The SMART library

SMART

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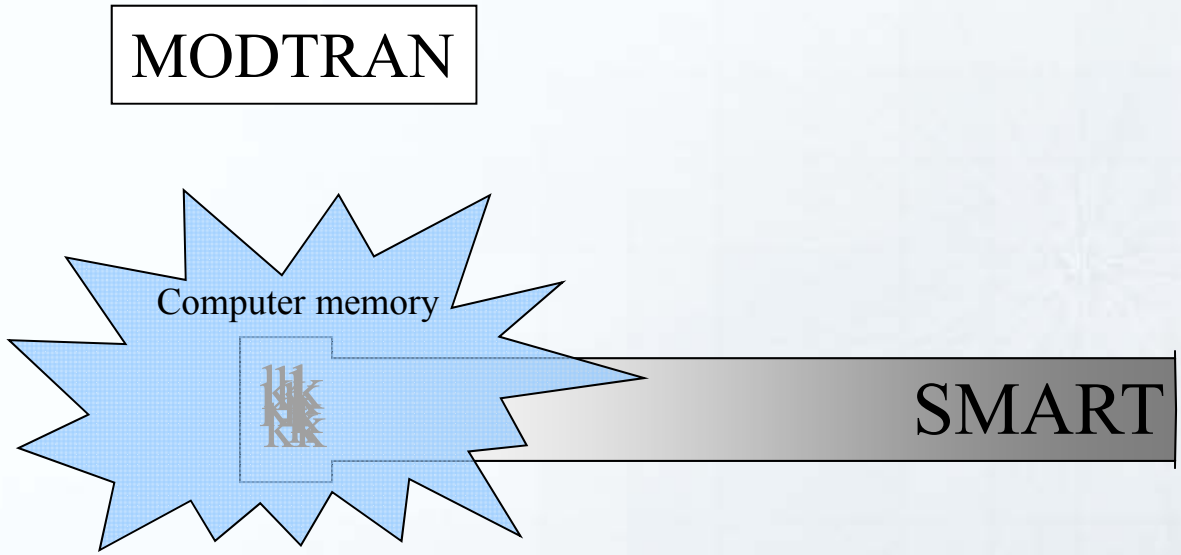
I nterface

The SMART library

- SMART (1.0 beta) features
  - Spectral and wideband CK transmittance & radiance
  - MODTRAN molecular extinctions (CK)
    - Seamless integration of MOD4v3r1
  - MODTRAN and DRDC aerosol models
  - Falling snow model (DRDC)
  - DRDC accurate refracted path calculation
  - 2-stream (flux) and DISORT (N-stream) MS calculations
  - Lambert and sea surface (DRDC analytical model) BRDF. Others to come.
  - Optimized by using advanced C++ programming methods
    - Intuitive like C++, fast like Fortran/C

The SMART library

- No modifications to the MODTRAN source code is necessary
  - Works with the official MODTRAN4 executable
  - Plans to support MODTRAN 5 in the near future



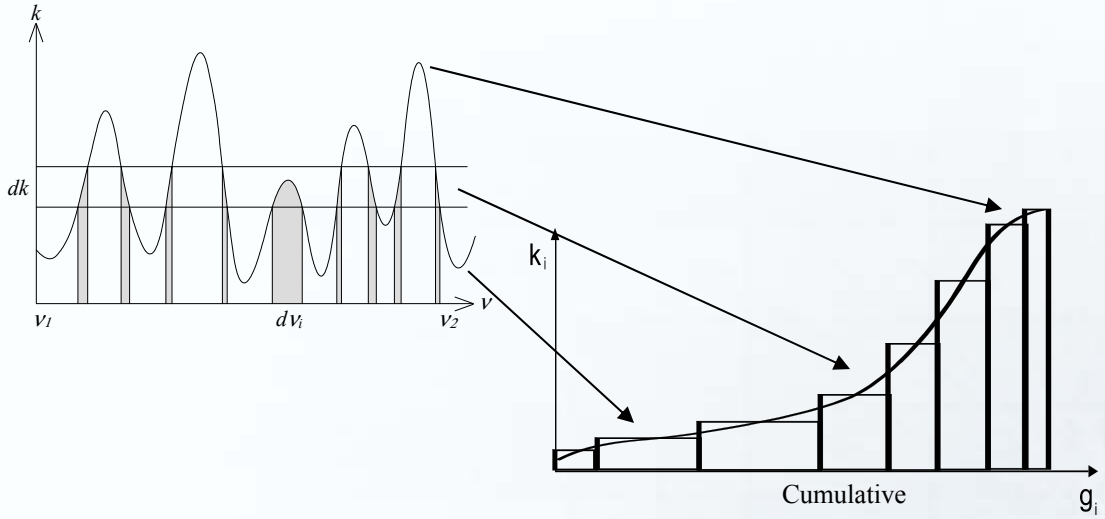
The SMART library

- High language portability (SMARTI)
  - C++ (native)
  - Java
  - Matlab (trough Java)

- Other language wrappers are possible/planned
  - Python, C#, Lisp, Lua, Octave, Pearl, PHP, Pike, TCL, R, Ruby, and more…

The correlated-k theory

- Transformation to Correlated-K space



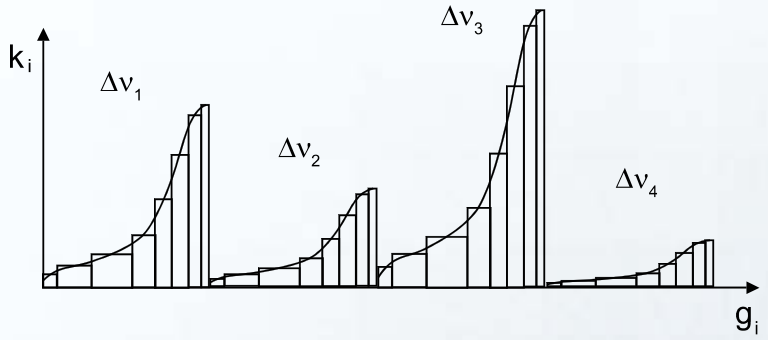
- Monotonic function need much fewer points to be represented accurately

$$T = \sum_i \exp\left(-k_i(g)\cdot s\right)\Delta g_i$$

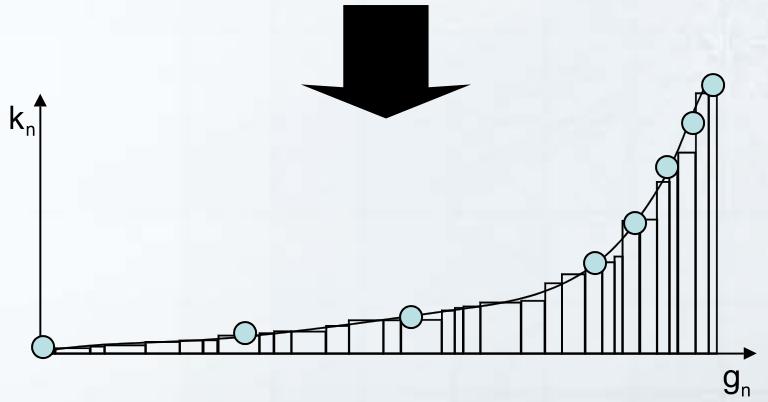
Wideband correlated-ks

- Converting MODTRAN4™ CK extinctions to wideband CK

1) Sort

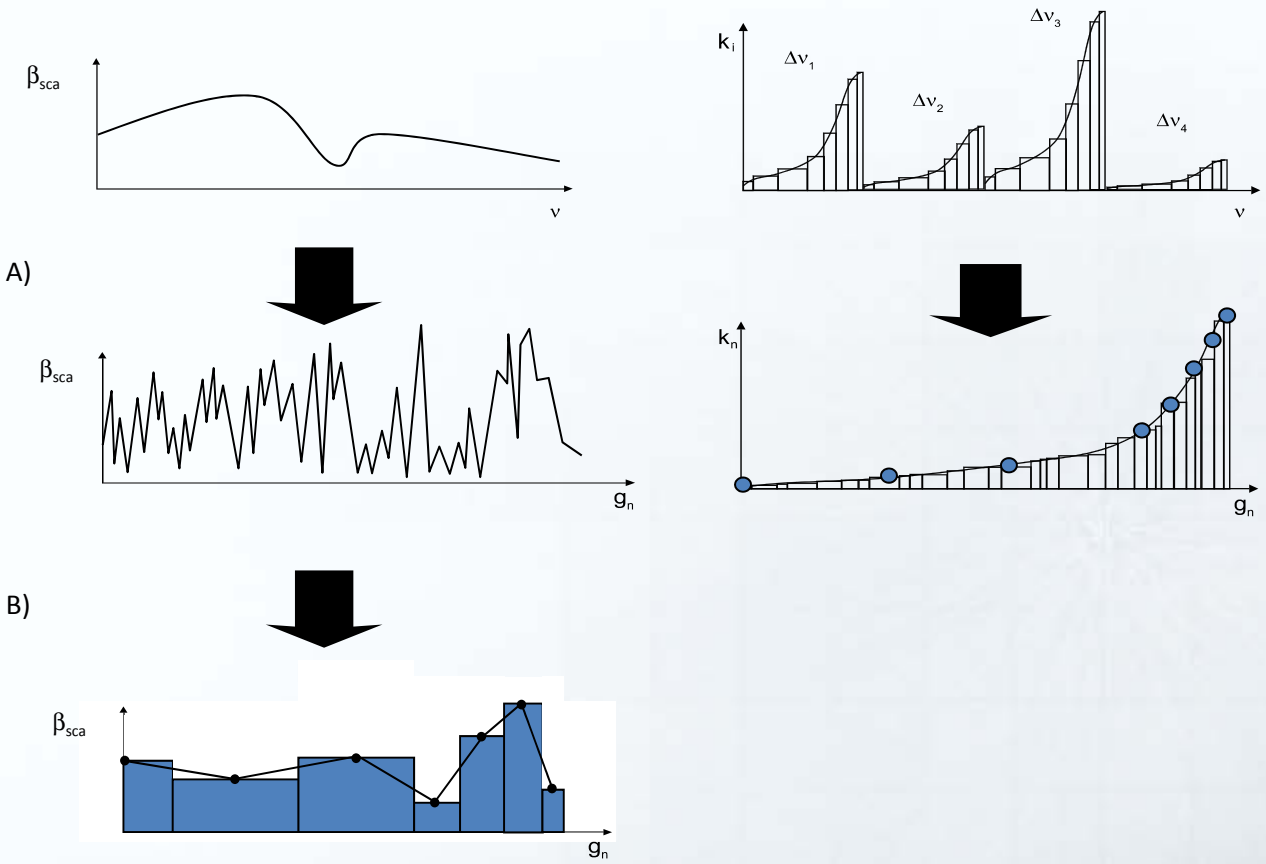


2) Interpolate



Wideband correlated-ks

- Converting other quantities to wideband CK space



Benefits

- Speed (wideband)
  - Over 1000 lines of sight per second (excluding initialization) in single and 2-flux multiple scattering
  - 50 lines of sight per second with 16 stream DISORT.

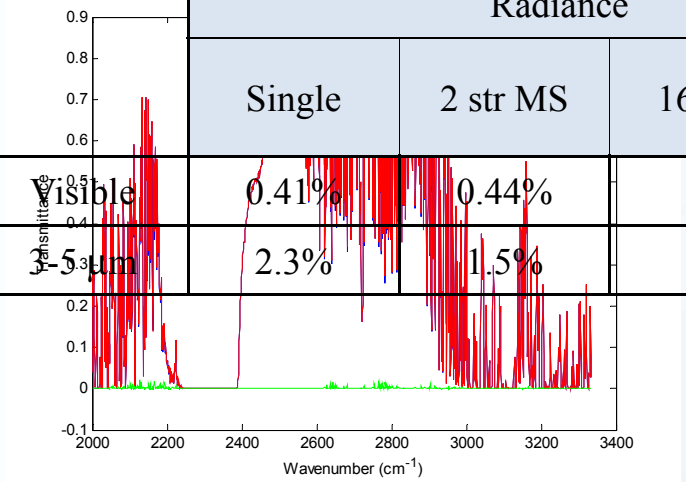
	Wide band CK			MODTRAN 4		
	Single (17 ck)	2 Str MS	16 Str DISORT	Single	2 Str MS	16 Str DISORT
Visible	0.00078 s	0.00125 s	0.166 s	0.83 s	2.86 s	3061 s
3-5 μm	0.00124 s	0.00234 s	0.19 s	1.05 s	3.08 s	1586 s

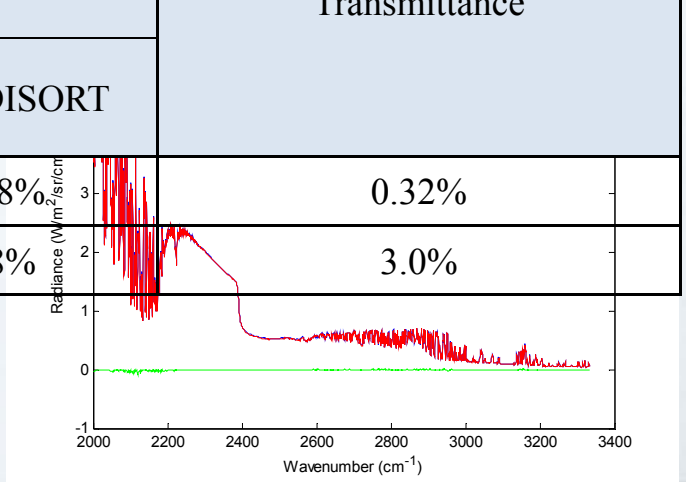
(Excluding initializing phase)

Benefits

- Accuracy
  - Spectral results are almost identical to MODTRAN 4.
  - Wideband radiance results are within 5% of full MODTRAN 4 calculations

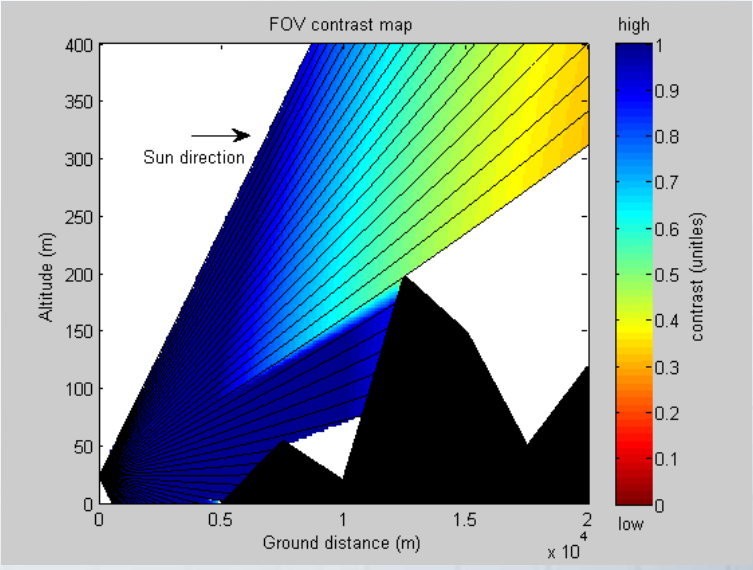
	Radiance			Transmittance
	Single	2 str MS	16 str DISORT	
Visible	0.41%	0.44%	0.18%	0.32%
3-5 μm	2.3%	1.5%	1.8%	3.0%





Applications

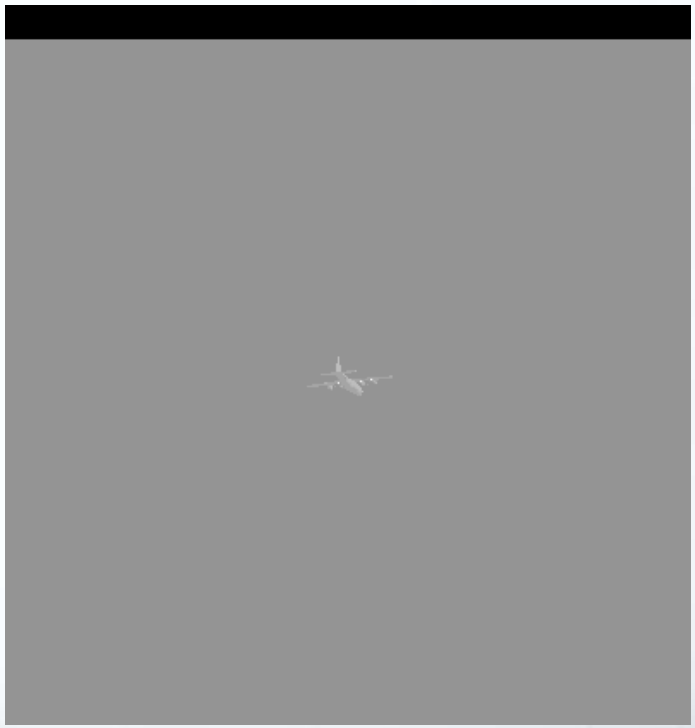
- Scene modeling:
  - Simulators
  - Assessing target detection/tracking algorithms.
  - Training
- EOTDA applications:
  - Contrast maps
  - Detection probability
  - “What if” scenarios
    - (requires especially optimized RT codes)
- Modeling for multi-spectral detectors.

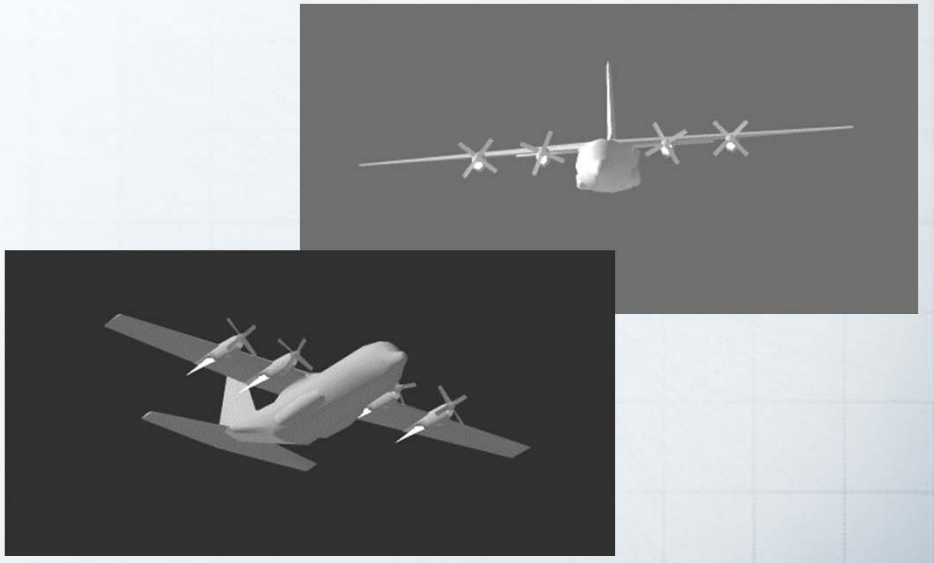


Current projects: KARMA simulation framework

IR scene Generation:

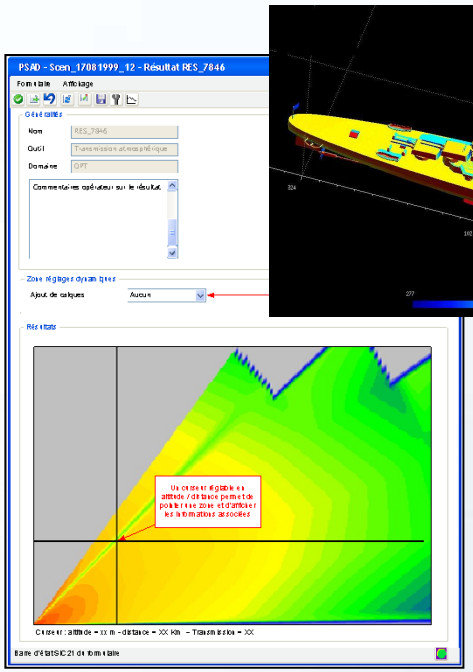
- IR scene = Input to the seeker models
- SMART atmosphere model
  - Dynamic atmospheric properties
  - Wideband-CK computations

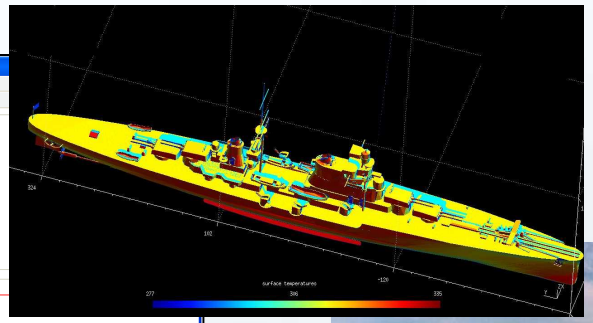


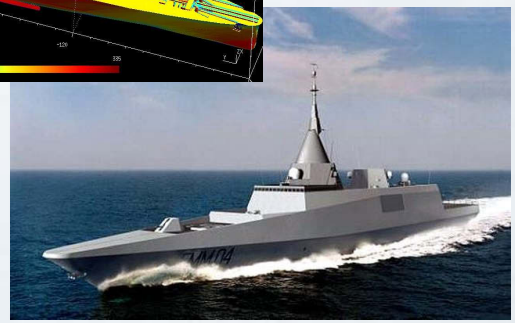


Current projects: MPIR (PSAD)

- PSAD-MPIR on the French FREMM (Multi Mission European FRigate) for DCNS







Thermal ship image courtesy of Fabian Lapierre, Royal Naval Academy of Belgium. (Computed using OSMOSIS)

Conclusion

- SMART(I) v1.0 beta is now ready.
- SMARTI is already in use in Canadian/International collaborative projects
- Interested beta users are welcome (vross@aerex.ca).
- Imaging, multispectral and EOTDA applications would benefit
- Divergence from MODTRAN 4 in radiance and transmittance are below 5% for most visible and IR bands in wide CK mode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